

Risk for Prostate Cancer by Occupation and Industry: A 24-State Death Certificate Study

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Current knowledge of the etiology of prostate cancer is limited. Numerous studies have suggested that certain occupations and industries may be associated with the occurrence of prostate cancer. Information on occupation and industry on death certificates from 24 states gathered from 1984 to 1993 was used in case control study on prostate cancer. A total of 60,878 men with prostate cancer as underlying cause of death was selected and matched with controls who died of all other causes except cancer. Similar to the findings of our parallel large case control study of prostate cancer, we observed excess risks in some white-collar occupations, such as administrators, managers, teachers, engineers, and sales occupations. However, some blue-collar occupations, such as power plant operators and stationary engineers, brickmasons, machinery maintenance workers, airplane pilots, longshoremen, railroad industry workers, and other occupations with potential exposure to PAH also showed risk of excess prostate cancer. Risk was significantly decreased for blue-collar occupations, including farm workers, commercial fishermen, mechanics and repairers, structural metal workers, mining, printing, winding, dry cleaning, textile machine operators, cooks, bakers, and bartenders. Although we observed excess risks of prostate cancer among some low socioeconomic status (SES) occupations, the overall results suggest that the effects of higher SES cannot be ruled out in associations between occupational factors and the risk of prostate cancer. Am. J. Ind. Med. 34:413–420, 1998. © 1998 Wiley-Liss, Inc.

KEY WORDS: prostate cancer; death certificate; case control study; occupation; industry

INTRODUCTION

Prostate cancer is one of the most frequent tumors in males though unequally distributed throughout the world [Muir et al., 1991]. This cancer is particularly frequent in North America and in several European countries, while very rare in much of Asia [Chiarodo, 1991]. In the United States, prostate cancer is the most commonly diagnosed

cancer and is the second leading cause of cancer death in men, and the rates are still increasing [Garnick, 1994; Ross and Schottenfeld, 1996]. An estimated 200,000 new cases were diagnosed in the United States during 1994 and there were 40,000 deaths [Nomura and Kolonel, 1991]. The African American population of the United States has the highest rate in the world [Chiarodo, 1991].

Current knowledge of the etiology of prostate cancer is limited. Genetics, endocrine status, diet, smoking, and environmental risk factors have been implicated, but the findings are not consistent [Ross and Schottenfeld, 1996]. Numerous studies have suggested that certain occupations and industries may be associated with the occurrence of prostate cancer, including farmers [Checkoway et al., 1987; Saftlas et al., 1987; Brownson et al., 1988; Blair and Hoar Zahm, 1992; Fincham et al., 1992; Blair et al., 1993; Dosemeci et al., 1994; Van der Gulden et al., 1995; Keller-Byrne et al., 1997], metal workers [Van der Gulden et

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al., 1992, 1995; Aronson et al., 1996; Van der Gulden, 1997], mechanics and repair men [Brownson et al., 1988; Abd Elghany et al., 1990; Van der Gulden et al., 1992, 1995; Aronson et al., 1996; Van der Gulden, 1997], rubber workers [Nomura and Kolonel, 1991; Ross and Schottenfeld, 1996; Weiland et al., 1996], and nuclear workers [Beral et al., 1985, 1988; Rooney et al., 1993], as well as exposures to cadmium [Abd Elghany et al., 1990; Nomura and Kolonel, 1991; Van der Gulden et al., 1995; Ross and Schottenfeld, 1996], pesticides [Morrison et al., 1993; Aronson et al., 1996; Kross et al., 1996; Van der Gulden and Vogelzang, 1996], fertilizers [Morrison et al., 1993; Kross et al., 1996; Van der Gulden and Vogelzang, 1996; Hoar Zahm et al., 1997], cutting oils [Siemietycki et al., 1987; Silverstein et al., 1988; Tolbert et al., 1992; Van der Gulden et al., 1995], lubricating oils and greases [Siemietycki et al., 1987, 1988; Van der Gulden et al., 1992, 1995], and PAHs [Costantino et al., 1995; Nadon et al., 1995; Aronson et al., 1996]. We evaluated the association between usual occupation and industry with prostate cancer in two data sets. This report presents the findings of a death certificate-based occupational mortality study conducted in 24 states of the United States. The findings of our parallel large case-control study of prostate cancer are presented also in this issue as a separate report.

METHODS

Death certificate-based occupational mortality data developed by the National Cancer Institute, National Institute for Occupational Safety and Health, and the National Center for Health Statistics were used [Burnett, 1997]. Since 1984, participating states (Colorado, Georgia, Idaho, Indiana, Kansas, Kentucky, Maine, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Rhode Island, South Carolina, Tennessee, Utah, Washington, West Virginia, Wisconsin, Vermont) have coded usual occupation and industry titles on death certificates using the 1980 Bureau of the Census Occupational and Industrial Classification System [U.S. Bureau of the Census, 1982].

Cases for this analysis were Caucasian and African American men whose death certificates listed prostate cancer as underlying cause of death (International Classification of Diseases, 9th revision, Code 185) for 1984–93. Subjects who died of all other causes except cancer were selected as the controls and matched to cases by age (5-year age groups) and race in a 1/5 ratio. A total of 60,878 men died of prostate cancer as the underlying cause, 9,750 were African American men (16.02%) and 51,128 were Caucasian (83.98%). This racial distribution among subjects with prostate cancer was in accord with the racial distribution in those 24 states [Burnett, 1997].

We evaluated risk of prostate cancer for each three-digit occupation or industry code among Caucasian and African

American males. Military, retired, decedent with no occupation reported, homemaker, student, volunteer, and never worked or disabled occupational codes were added to the original 1980 census list. We calculated age-adjusted (five-year-interval) mortality odds ratio (MORs) for prostate cancer (case group) for each individual occupation and industry (exposed group) against all occupations/industries combined (unexposed group) using all causes of death except cancer as a control group. All mortality odds ratios are reported with 95% confidence intervals (95% CI) with lower and upper limits rounded to one significant digit. We only presented MORs for occupations and industries with at least five exposed cases and/or statistically significant MORs. We also evaluated risk for occupations and industries by four age groups (20–39, 40–59, 60–74, and >75) and five geographic regions with at least 50 cases.

RESULTS

Of 553 individual occupations with minimum 5 cases, 84 have statistically significant increased MORs (Table I) and 38 have statistically significant decreased MORs (Table II). Among Caucasian men, we observed twofold or more increased risks for nuclear and agricultural engineers, surveyors, physicists, biologists, engineering, agricultural and other teachers, archivists, urban planners, mechanical technicians, chief communication operators, graders (agricultural production), captains (fishing vessels), and longshore equipment operators. African American men who were chief executives, administrators in education, secondary-school teachers, lawyers, sales workers in mining, firefighters, machinery maintenance workers, supervisor (brickmasons), knitting and extruding machine operators had twofold or more increased risk for prostate cancer. Among Caucasian men, we observed statistically significant decreased risk with MOR less than 0.5 for elevator operators, recreational attendants, personal service occupations, motion picture projectionists, garbage collectors, and homemakers, while among African Americans, only homemakers had risk less than 0.5 (Table II). Risk for prostate cancer was significantly lower for both Caucasians and African Americans who were unemployed and disabled.

We presented MORs by industry classification in Table III. Of 358 various industries with 5 or more cases, there were 51 significantly increased MORs and 20 decreased MORs. None of the three-digit individual industries showed a risk greater than 2.0 among Caucasian men. Several industries such as drug manufacturing, furniture and petroleum production, business management services, offices of chiropractors, educational and scientific research services showed slightly elevated risk; however, most of the MORs were less than 1.5. Among African American men, we observed excess risk for prostate cancer with MOR of 2.0 or

TABLE I. Significantly Increased Mortality Odds Ratios (MOR) of Prostate Cancer, 95% Confidence Interval (CI), and Number of Cases in White and African American Males by Occupational Code in Death Certificate Study in 24 States

Occupation	Cases exposed	MOR	95% CI
Chief executives (004)	5 ^a	2.4 ^a	1.1–5.1 ^a
Administrators and officials (005)	256	1.3	1.1–1.4
Financial managers (007)	94	1.3	1.0–1.6
Personnel managers (008)	57	1.7	1.3–2.3
Purchasing managers (009)	35	1.4	1.0–2.0
Managers, marketing, advertising (013)	192	1.4	1.2–1.6
Administrators, education (014)	186	1.6	1.4–1.9
	39 ^a	2.1 ^a	1.5–2.1 ^a
Managers, N.E.C. (019)	3,885	1.2	1.2–1.3
Other financial officers (025)	144	1.4	1.2–1.7
Personnel, training (027)	56	1.4	1.0–1.8
Buyers, wholesale and retail (029)	63	1.5	1.1–1.9
Architects (043)	76	1.6	1.3–2.0
Aerospace engineers (044)	58	1.4	1.0–1.8
Chemical engineers (048)	89	1.5	1.2–1.9
Nuclear engineers (049)	7	3.0	1.5–6.0
Civil engineers (053)	335	1.3	1.2–1.5
Agricultural engineers (054)	5	2.9	1.2–6.0
Electrical engineers (055)	312	1.5	1.3–1.6
Industrial engineers (056)	119	1.4	1.2–1.7
Mechanical engineers (057)	243	1.5	1.3–1.7
Engineers, N.E.C. (059)	106	1.3	1.1–1.6
Surveyors, mapping scientists (063)	15	2.1	1.3–3.5
Physicists and astronomers (069)	17	2.0	1.2–3.3
Chemists, except biochemists (073)	94	1.3	1.0–1.5
Atmospheric scientists (074)	94	1.3	1.0–1.5
Geologists and geodesists	33	1.7	1.2–4.0
Agricultural scientists (077)	24	1.5	1.0–2.3
Biological and life scientists (078)	16	2.0	1.2–3.4
Physicians (084)	314	1.5	1.3–1.6
Dentists (085)	103	1.2	1.0–1.5
Optometrists (087)	26	1.5	1.0–2.3
Health practitioners, N.E.C. (089)	34	1.8	1.2–2.5
Engineering teachers (127)	12	2.1	1.2–3.8
Agricultural teachers	11	3.1	1.7–5.4
Teachers, postsecondary, n.s. (154)	126	1.5	1.2–1.8
Teachers, elementary school (156)	431	1.3	1.2–1.4
	93 ^a	1.7 ^a	1.3–2.1 ^a
Teachers, secondary school (157)	136	1.6	1.3–1.9
	16 ^a	2.4 ^a	1.5–4.1 ^a
Teachers, N.E.C. (159)	16	2.4	1.5–4.1
Archivists and curators (165)	9	2.2	1.2–4.3
Economists (166)	19	1.8	1.2–2.9
Urban planners (173)	8	6.7	3.8–12.0
Clergy (176)	516	1.4	1.2–1.5
Lawyers (178)	316	1.4	1.3–1.6
	10 ^a	2.1 ^a	1.1–4.1 ^a

TABLE I. Significantly Increased Mortality Odds Ratios (MOR) of Prostate Cancer, 95% Confidence Interval (CI), and Number of Cases in White and African American Males by Occupational Code in Death Certificate Study in 24 States (continued)

Occupation	Cases exposed	MOR	95% CI
Public relations specialists (197)	28	1.5	1.0–2.2
Athletes (199)	32	1.4	1.0–2.0
Mechanical technicians (215)	8	2.2	1.1–4.5
Engineering technicians, N.E.C. (216)	61	1.3	1.0–1.7
Surveying technicians (218)	39	1.5	1.1–1.7
Airplane pilots and navigators (226)	37	1.4	1.0–2.0
Real estate sales occupations (254)	296	1.2	1.1–1.4
	16 ^a	1.9 ^a	1.2–3.2 ^a
Sales workers, mining (259)	667	1.2	1.1–1.3
	14 ^a	2.0 ^a	1.1–3.3 ^a
Supervisors, financial (305)	19	1.9	1.2–3.0
Chief communications operators (306)	7	2.3	1.1–4.8
Supervisors, distribution (307)	16 ^a	1.8 ^a	1.1–3.0 ^a
Mail carriers, postal service (355)	291	1.2	1.1–1.4
Insurance adjusters (375)	40	1.4	1.0–1.9
Firefighting occupations (417)	140	1.2	1.0–1.4
	13 ^a	2.2 ^a	1.2–3.9 ^a
Police and detectives (418)	20 ^a	1.6 ^a	1.0–2.5 ^a
Graders, agricultural prod. (488)	5	4.6	1.9–11.0
Captains, fishing vessels (497)	5	2.5	1.1–6.1
Machinery maintenance workers (519)	9 ^a	2.4 ^a	1.2–4.7 ^a
Household appliance repairers (526)	39	1.4	1.0–2.0
Supervisors, brickmasons (553)	5 ^a	2.9 ^a	1.4–6.0 ^a
Supervisors, painters (556)	69	1.3	1.0–1.6
Supervisors, N.E.C. (558)	522	1.2	1.1–1.3
Supervisors, production (633)	77 ^a	1.4 ^a	1.1–1.7 ^a
Power plant operators (695)	54	1.6	1.2–2.1
Stationary engineers (696)	333	1.2	1.0–1.3
	30 ^a	1.8 ^a	1.2–2.6 ^a
Knitting, weaving machine operators (739)	18 ^a	2.0 ^a	1.2–3.2 ^a
Extruding machine operators (755)	6 ^a	2.4 ^a	1.1–5.4 ^a
Furnace, kiln, and oven operators (766)	61 ^a	1.3 ^a	1.0–1.7 ^a
Bus drivers (808)	47 ^a	1.4 ^a	1.0–1.8 ^a
Operating engineers (844)	37 ^a	1.4 ^a	1.0–2.0 ^a
Longshore equipment operators (845)	6	2.7	1.3–5.6
Military (905)	759	1.2	1.1–1.3

^aAfrican American men.

more among workers employed in electrical machinery, railroad locomotives, jewelry stores, security brokerage companies, and libraries.

We observed statistically significant decreased risk with MORs of less than 0.5 (Table IV) for the floor covering industry only among Caucasian men, and for automotive services among African American men. Both Caucasians and African Americans had lower MORs in coal mining,

TABLE II. Significantly Decreased Mortality Odds Ratios (MOR) of Prostate Cancer, 95% Confidence Interval (CI), and Number of Cases in White and African American Males by Occupational Code

Occupation	Cases exposed	MOR	95% CI
Bookkeepers, accounting clerks (337)	86	0.8	0.6–1.0
Guards and police, private (426)	302	0.8	0.7–0.8
Supervisors, food service (433)	52	0.8	0.6–1.0
Bartenders (434)	46	0.6	0.4–0.8
Cooks, except short order (436)	79	0.7	0.5–0.8
Miscellaneous food preparation workers (444)	22	0.6	0.4–0.9
Nursing aides, attendants (447)	40	0.7	0.5–1.0
Elevator operators (454)	6	0.4	0.2–0.8
Recreational attendants (459)	10	0.4	0.2–0.7
Personal service occupations (469)	6	0.3	0.1–0.7
Farm workers (479)	192	0.7	0.6–0.9
Fishers (498)	39	0.7	0.5–1.0
Automobile body repairers (514)	53	0.7	0.6–1.0
Mechanics and repairers, n.s. (549)	172	0.8	0.7–0.9
Structural metal workers (597)	65	0.8	0.6–1.0
Mining machine operators (616)	550	0.7	0.6–0.8
	61 ^a	0.7 ^a	0.5–0.9 ^a
Bakers (687)	91	0.8	0.6–1.0
Printing machine operators (734)	170	0.8	0.7–1.0
Winding machine operators (738)	80	0.8	0.6–1.0
Dry cleaning machine operators (748)	26	0.6	0.4–0.9
Misc. textile machine operators (749)	201	0.8	0.7–0.9
Motion picture projectionists (773)	10	0.5	0.3–0.9
Truck drivers, heavy (804)	1,138	0.8	0.8–0.9
Truck drivers, light (805)	87	0.8	0.6–1.0
Taxicab drivers and chauffeurs (809)	82	0.7	0.5–0.8
Locomotive operating occupations (824)	123	0.8	0.7–1.0
Garbage collectors (875)	13	0.5	0.3–0.9
	43 ^a	0.7 ^a	0.5–1.0 ^a
Freight, stock, N.E.C. (883)	82	0.8	0.6–0.9
Laborers, except construction (889)	1,685	0.8	0.8–0.8
Retired (913)	598	0.8	0.7–0.9
Homemaker (914)	5	0.1	0.0–0.2
	7 ^a	0.4 ^a	0.2–0.8 ^a
None (unemployed, disabled) (917)	139	0.4	0.3–0.4
	89 ^a	0.6 ^a	0.5–0.7 ^a
Unknown (999)	795	0.8	0.8–0.9
	221 ^a	0.7 ^a	0.7–0.9 ^a

^aAfrican American men.

when they were nonpaid workers, or when the industry was not reported on the death certificates.

We also evaluated high- and lower-risk occupations and industries by age group and geographic region. In some occupations (engineers, chemists, electrical machinery, electric, and gas, etc.), we observed excess risks in the younger

age group, suggesting potential exposures due to the introduction of new technologies and occupational hazards (data not presented). We did not observe major differences between five geographic regions.

DISCUSSION

We analyzed risk for prostate cancer for more than 60,000 cases in relation to their usual occupation, using a death certificate-based mortality data from 24 states of the U.S. Similar to the results of our parallel study [Krstev et al., in this issue], we observed excess risks of prostate cancer among various administrative and managerial occupations, firefighters, farmers, brickmasons, power plant operators, truck drivers, grader operators, and railroad workers. Among African American men, the highest odds ratios were observed for chief executives, administrators in education, and administrators and officials. Increased risk for prostate cancer was observed among a variety of engineers, urban planners, archivists and curators, lawyers, financial supervisors, natural scientists (physicists, chemists, physician, dentists, etc.), as well as in some sales workers (particularly among African Americans). Regarding the industry, elevated risks was found in commercial and scientific research services, engineering services, real estate offices, offices of physicians and chiropractors, legal services, economic and human resources programs.

These occupations reflect a higher category of socioeconomic status and they are predominantly sedentary in nature. The possible relationship between socioeconomic characteristics and the development of prostate cancer risk has been explored in several investigations, but no large differences in prostate cancer risk was found between men in the highest compared to those in the lowest socioeconomic strata [Ross and Schottenfeld, 1996; Smith et al., 1996]. The role of physical activity is still unclear. Both increased and decreased risks were reported with different levels of occupational physical activity [Le Marchand et al., 1991; Dosemeci et al., 1993; Hsing et al., 1994; Thune and Lund, 1994; Ilic et al., 1996].

Risks of prostate cancer among administrative workers and teachers have been inconsistent. Some studies reported excess risks for these occupations [Pearce et al., 1987; Brownson et al., 1988; Fincham et al., 1990; Le Marchand et al., 1991; Van der Gulden et al., 1992; Hsing et al., 1994; Rosenman, 1994] and others did not observe any association [Abd Elghany et al., 1990; Fincham et al., 1990; Le Marchand et al., 1991; Van der Gulden et al., 1992, 1995]. It is unlikely that administrative workers or teachers are exposed to potentially carcinogenic occupational factors. Engineers, however, could be exposed to some extent to numerous occupational hazards, including solvents, EMF, and ionizing radiation, but they should have a relatively “clean” work environment. Introduction of new technologies along with the new chemical and physical agents might

TABLE III. Significantly Increased Mortality Odds Ratios (MOR) of Prostate Cancer, 95% Confidence Interval (CI), and Number of Cases in White and African American Males by Industry Code

Industry	Cases exposed	MOR	95% CI
Agricultural production, livestock (011)	1,418	1.2	1.1–1.2
Not specified food industries (122)	79	1.3	1.1–1.7
Yarn, thread, fabric mills (142)	271 ^a	1.2 ^a	1.1–1.4 ^a
Drugs (181)	94	1.6	1.3–1.9
Cutlery, hand tools (281)	59	1.4	1.0–1.8
Electrical machinery (342)	393	1.2	1.0–1.3
	42 ^a	1.5 ^a	1.1–2.1 ^a
Electrical machinery, n.s. (350)	157	1.4	1.2–1.7
	15 ^a	2.9 ^a	1.7–5.0 ^a
Motor vehicle (351)	195 ^a	1.3 ^a	1.2–1.6 ^a
Railroad locomotives (361)	8 ^a	2.2 ^a	1.1–4.4 ^a
Missiles, space vehicle (362)	76	1.4	1.1–1.7
Miscellaneous transportation equipment (370)	30	1.5	1.0–2.2
Scientific instruments (371)	81	1.4	1.1–1.7
U.S. Postal service (412)	171 ^a	1.3 ^a	1.1–1.6 ^a
Radio and TV broadcasting (440)	64	1.4	1.1–1.8
Telephone (441)	327	1.3	1.1–1.4
Electric and gas (462)	110	1.3	1.1–1.6
	16 ^a	1.9 ^a	1.2–3.3 ^a
Furniture and home furnishings (501)	20	1.6	1.0–2.5
Electrical goods (512)	76	1.4	1.1–1.8
Petroleum production (552)	19 ^a	1.6 ^a	1.0–2.6 ^a
Farm supplies (561)	76	1.3	1.1–1.7
Hardware store (581)	163	1.3	1.1–1.5
Miscellaneous vehicle dealers (622)	28	1.5	1.0–2.2
TV and radio stores (640)	150	1.2	1.1–1.5
Jewelry stores (660)	5 ^a	2.0 ^a	1.1–3.9 ^a
Banking (700)	327	1.2	1.1–1.3
Security, brokerage companies (710)	112	1.3	1.1–1.6
	5 ^a	2.2 ^a	1.0–4.9 ^a
Insurance (711)	671	1.2	1.1–1.3
Real estate, law offices (712)	527	1.2	1.1–1.3
Advertising (721)	88	1.3	1.0–1.6
Commercial research labs (730)	51	1.5	1.1–2.0
Business management services (732)	54	1.7	1.3–2.2
Other logging places (770)	44	1.6	1.2–2.2
Offices of physicians (812)	283	1.5	1.3–1.7
Offices of chiropractors (821)	27	1.6	1.1–2.3
Legal services (841)	271	1.4	1.2–1.5
Elementary, secondary schools (842)	1,206	1.2	1.2–1.3
	348 ^a	1.4 ^a	1.3–1.6 ^a
Colleges and universities (850)	482	1.4	1.3–1.5
Libraries (852)	6 ^a	2.9 ^a	1.3–6.1 ^a
Educational services (860)	43	1.8	1.3–2.4
Religious organizations (880)	575	1.3	1.2–1.4
Engineering services (882)	276	1.4	1.2–1.6
Scientific research services (891)	34	1.7	1.2–2.4

TABLE III. Significantly Increased Mortality Odds Ratios (MOR) of Prostate Cancer, 95% Confidence Interval (CI), and Number of Cases in White and African American Males by Industry Code (continued)

Industry	Cases exposed	MOR	95% CI
Miscellaneous professional services (892)	68	1.4	1.1–1.8
Executive offices (900)	66	1.3	1.0–1.7
Human resources programs (922)	115	1.2	1.0–1.5
Economic programs (931)	224	1.2	1.1–1.4

^aAfrican American men.**TABLE IV.** Significantly Decreased Mortality Odds Ratios (MOR) of Prostate Cancer, 95% Confidence Interval (CI), and Number of Cases in White and African American Males by Industry Code

Industry	Cases exposed	MOR	95% CI
Coal mining (041)	558	0.7	0.6–0.8
	70 ^a	0.8 ^a	0.6–1.0 ^a
Bakery products (111)	143	0.8	0.7–1.0
Floor covering (141)	11	0.4	0.2–0.7
Footwear, except rubber (221)	125	0.8	0.7–1.0
Miscellaneous mineral and stone production (262)	57	0.6	0.5–0.8
Taxicab service (402)	66	0.6	0.5–0.8
Trucking service (410)	893	0.8	0.8–0.9
Sanitary service (471)	79	0.8	0.6–1.0
	83 ^a	0.8 ^a	0.6–1.0 ^a
Eating and drinking places (641)	520	0.8	0.7–0.9
Detective services (741)	73	0.7	0.6–0.9
Automotive services (750)	68 ^a	0.4 ^a	0.2–0.9 ^a
Laundry, cleaning services (771)	154	0.8	0.7–1.0
Beauty shops (772)	14	0.6	0.3–1.0
Membership organizations (881)	80	0.8	0.6–0.9
Nonpaid worker or nonworker (961)	133	0.3	0.3–0.4
	91 ^a	0.6 ^a	0.5–0.7 ^a
Industry not reported (990)	851	0.8	0.7–0.8
	420 ^a	0.8 ^a	0.7–0.9 ^a

^aAfrican American men.

be responsible for higher rates in these professionals. In some investigations, broad groups of professionals and especially engineers had moderately elevated risk [Pearce et al., 1987; Hrubec et al., 1992; Hsing et al., 1994], while in others, a deficit has been observed [Le Marchand et al., 1991]. Fincham et al. [1990] found no elevated risk for those who reported work in the natural sciences (RR = 1.02). In a study in the U.S. [Abd Elghany et al., 1990], although no overall excess was observed among physicians and dentists, the risk was slightly elevated when only aggressive tumors

were considered. An investigation in China found significantly increased risk for prostate cancer in medical and public health workers [Hsing et al., 1994], as well as study among U.S. veterans [Hrubec et al., 1992]. Sales workers showed slightly elevated risk in some studies [Pearce et al., 1987; Abd Elghany et al., 1990; Fincham et al., 1990; Hrubec et al., 1992; Van der Gulden et al., 1992], while in retail trade risk was insignificantly decreased [Van der Gulden et al., 1995].

Excess risk of prostate cancer among firefighters was found in our study, particularly among African American men. Findings from the U.S., Canada, and Sweden also found elevated risks for firefighters, but they were not statistically significant [Guidotti, 1993; Demers et al., 1994; Tornling et al., 1994]. Firefighters are exposed to complex mixtures of toxic gases, fumes, and particles due to the increasing introduction of plastics and other synthetic compounds into building materials and furnishings. Currently, the most common carcinogens present in the fire smoke are benzene, PAHs (i.e., benzo(a)pyrene), and asbestos [Demers et al., 1994; Nadon et al., 1995].

Usual occupation such as power plant operator and particularly stationary engineer showed excess in risk. This group of workers is usually exposed to benzo(a)pyrenes, PAHs from coal and fuel oil, asbestos, and soot [Nadon et al., 1995; Aronson et al., 1996], as well as to high levels of physical activity. A cohort study of a broad group of electric utility workers found decreased risk for prostate cancer among power plant operators [Kelsh and Sahl, 1991]. We observed excess risk for African American machinery maintenance workers. Recently, it has been suggested that various metal workers have a slightly increased risk for prostate cancer [Van der Gulden, 1997]. The specific factors that might pose as risks in the metal industry are still unknown, although various metals [Checkoway et al., 1987; Abd Elghany et al., 1990; Le Marchand et al., 1991; Van der Gulden et al., 1992, 1995], cutting oils [Siemietycki et al., 1987; Park et al., 1988; Silverstein et al., 1988; Tolbert et al., 1992; Van der Gulden et al., 1995; Park and Mirer, 1996], and some solvents [Bethwaite et al., 1990; Anttila et al., 1995; Van der Gulden et al., 1995; Aronson et al., 1996] could be involved. We observed elevated risk of prostate cancer among brickmasons supervisors; however, there were only five deaths in this occupational category. Work in this occupation may result in exposure to some known carcinogens (e.g., silica, asbestos), but they have not been related to prostate cancer. Studies reporting prostate cancer risk in brickmasons [Hall and Rosenman, 1991], and in the broad group of construction workers, have not found any excess of risk [Le Marchand et al., 1991; Keller and Howe, 1993; Robinson et al., 1995; Van der Gulden et al., 1995]; however, risk was increased among U.S. veterans [Hrubec et al., 1992]. In contrast to the similar study conducted in Washington state [NIOSH, 1997], we found elevated risks

for some other blue-collar occupations, including knitting and weaving machine operators, extruding machine operators, operating engineers (all among African Americans), and captains, fishing vessels and longshore equipment operators (among Caucasian men), and industries such as yarn, thread, fabric and mill (for African Americans), electrical machinery (for Caucasians), miscellaneous transport equipment, electrical and gas, furniture, and petroleum production. Railroad locomotive work was also associated with increased risk for prostate cancer, especially among African American men. Workers in the railroad industry may be exposed to the diesel engine exhaust, containing PAHs, asbestos, and creosote. A study in Canada found nonsignificantly elevated risk in railroad transport industry [Aronson et al., 1996].

Our findings indicated that Caucasian airplane pilots and navigators had slightly increased mortality rates for prostate cancer, suggesting a potential role of exposure to ionizing radiation, ozone, and jet engine emissions. A recently published study also reported nonsignificantly increased mortality rates and significantly increased incidence rates for prostate cancer in Canadian airline pilots [Band et al., 1996].

Slightly elevated risk was also found for athletes. The possible role of physical activity on the development of prostate cancer is not clear. It has been suggested that athletes have lower basal levels of circulating testosterone than untrained men [Rosenman, 1994], but testosterone is suspected to play an important role in the development of prostate cancer [Le Marchand et al., 1991; Ross and Schottenfeld, 1996]. Wide use of anabolic steroids in young athletes could affect the development of prostate cancer.

Data from our study showed decreased risk for the different farmer's occupations, and no excess in risk for agricultural production, except a slight elevation among livestock farmers. Much attention has been paid to farmers, as data suggested that they have higher rates for prostate cancer than the general population, in spite of their overall lower mortality [Blair et al., 1992, 1993; Blair and Hoar Zahm, 1995]. The similar U.S. study based on death certificates in 24 states from 1984 to 1991 indicated that about 38% of the excess prostate cancer mortality among African American men may be associated with farming [Dosemeci et al., 1994]. Some studies also suggested increased risk for farmers and agricultural activities [Brownson et al., 1988; Abd Elghany et al., 1990; Fincham et al., 1990, 1992; Van der Gulden et al., 1995; Aronson et al., 1996; Keller-Byrne et al., 1997], while others were not able to find any excess of risk [Pearce et al., 1987; Ronco et al., 1992; Morrison et al., 1993; Wiklund and Dich, 1995]. No specific farm exposure has been clearly identified. Significantly decreased risk is also found for various blue-collar occupations (mechanics and repairers, structural metal workers, mining, printing, dry cleaning and textile machine

operators, truck and taxi drivers, garbage collectors, etc.) exposed to different possible carcinogenic chemical and physical agents.

The role of the different occupational factors in the development of prostate cancer is not clear. Analyses of death certificates for this 10-year period allowed us to study a large number of prostate cancers, both in Caucasians and African Americans. In reporting the cause of death, occupation or industry errors can occur, and we are aware of possible shortcomings [Hernberg, 1992; Selikoff, 1992a, 1992b]. Death certificates include only the usual occupation and we lack data on duration in occupation or industry and other possible risk factors. In spite of this, these data are of value because of the large number of deaths available for analysis. Increased risk was more often seen in white-collar occupations (i.e., administrators, managers, teachers, engineers, sales occupations, etc.); however, similar to the findings of our parallel study, we also observed excess risks in power plant operators and stationary engineers, brickmasons, machinery maintenance workers, indicating the possible role of combustion products, such as PAHs or diesel exhaust. Although we observed some clues about potential occupational risk factors for prostate cancer, this study and a parallel large case control study of prostate cancer [Krstev et al, in this issue] did not provide strong evidence that could account for a substantial proportion of prostate cancer in the U.S.

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